# PRINCIPLES OF ECONOMIC EVALUATION OF URANIUM RESOURCES IN CANADA

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**Abstract**

The uranium resources of Canada occur in deposits associated with unconformities in Proterozoic basins and adjacent areas. Classification of the resources is based on the confidence in the estimates and on their economic viability. The system is fully compatible with IAEA/NEA classified systems. The methods of estimating and classifying the Canadian resources is described.

## PRESENT STATUS OF URANIUM RESOURCES

Uranium resources of all technical and economic categories occur in deposits associated with unconformities in Proterozoic basins and adjacent areas. The resources associated with other types of deposits either have been depleted or are under present market conditions uneconomic.

The largest amounts of the economic resources have been identified in the Saskatchewan part of the Athabasca Basin. Individual deposits there contain large quantities of high grade resources (e.g. the McArthur River (P2 North) deposit contains 160 000 tonnes U in ores grading 12.7% U, the Cigar Lake deposit contains 150 000 tonnes U in ores grading 7.8% U).

The remaining economic resources have been identified in the Northwest Territories in deposits which occur in rocks associated with the Thelon Basin.

If and when it is required due to actual or long range economic (market) conditions, the quantities of resources are revised (e.g. due to termination of contracts for deliveries of uranium concentrates from the Elliot Lake quartz-pebble conglomerate deposits, their resources have been reclassified as uneconomic).

## TECHNICAL-ECONOMIC ASPECTS OF RESOURCE EVALUATION

Classification of the resources is based on the confidence in their estimates and on their economic viability. The classification system is fully compatible with the IAEA/NEA classification scheme as documented in the "Red Book".

In respect to confidence in the estimates, the classification takes into account the calculated (geostatistical et al.) or empirical (per analogiam) parameters, which determine the requirements for type, density and technical conditions of sampling.

The classification according to the economic viability is based upon establishing economic cut-off grades.

## QUANTITATIVE ASSESSMENT

The resources are reported as quantities of metal recoverable from ores (i.e. after taking into account (subtracting) losses of metal during the mining and milling processes.

Exploitation method (mining, in situ leaching (ISL) etc.) has to be clearly defined and must accompany the estimated quantities.

However, in order to facilitate optimization of the operations and eventual revisions of the resources due to changing technical-economic conditions, the data base should contain estimates of resources "in situ" as well as quantities of resources at "multiple" cut-of grades.

## CONCEPT OF CLASSIFICATION INTO COST CATEGORIES

The first phase of the classification is based on *break-even* principle, which correspond with the lowest possible cut-off grade. The input for this phase includes all the estimated basic costs: (a) operation, (b) capital investment, (c) taxes, royalties and legal, (d) additional R&D and exploration, (e) environmental impact, (f) decommissioning, (g) contingency.

The economic categorization takes into account additional factors, such as interest on borrowed money, expected profit etc.

The calculations are conducted according to the formula:

$$COG = (I+MD) \times (C/P+ML) - (DG) \times (MD), \text{ where:}$$

| | | |
|---|---|---|
| COG | = | cut-off grade in kg U/tonne of ore |
| MD | = | mining dilution (in decimal) |
| C | = | total costs in $/tonne |
| P | = | price in $/kg U |
| ML | = | mining losses in kg U/tonne, and |
| DL | = | dilutant grade. |

During the life of the property, the cut-off grades may change in order to reflect financial status of the operation at any point in time. Capital and production costs are the most influential variables that affect the cut-off grades and economic structure of the resources. Because of dynamic nature of the uranium market, optimization studies during the mine operations are inevitable.

For that reason computer-assisted economic models employing multiple cut-off grades scenarios are useful tools for global assessment of the viability of the resources during the life of the property. An important part of these models are the grade/tonnage curves.

## FEASIBILITY STUDIES

The most important document for the decision to start the exploitation of a deposit is a feasibility study. It represents an audit of ore reserve estimates, engineering and cost-related parameters. It should include a risk analysis, where probability distributions are shown for each key parameter. It must be a basis for optimal use of mineral resources under optimal economic conditions.

A feasibility study may change final classification or size of mineral resources. For example an appraisal of uranium resources of the Cigar Lake deposit before completion of the feasibility study was 110 000 tonnes of uranium metal in ores grading 12.2% U. The final feasibility study demonstrated that the deposit can yield 150 000 tonnes of uranium from ores grading 7.8% U.